Using Optical Physics to Mimic Superpowers!

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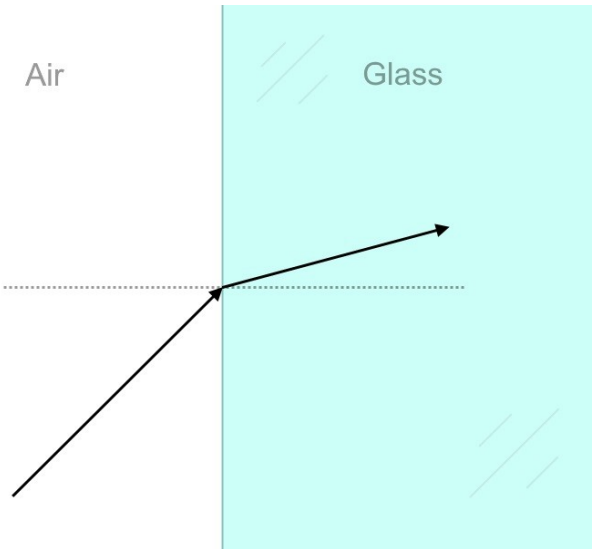
Have you seen online videos of the water-absorbing polymer orbs (often sold under the brand name Orbeez)? At first glance, the transparent orbs appear nearly invisible when placed in water, but are clearly visible when held in your palm. How is this possible – and – what if you could replicate this strange phenomenon to make yourself invisible?

Let's talk some optical physics! The way we perceive an object involves three vital components: our eyes, a source of light, and our brain. Imagine: A lightbulb emits electromagnetic waves in the visible part of the spectrum (and some not so visible). Those same waves bounce off an object, say a neon yellow tennis ball, and enter the lens in our eyes. The waves then focus on the retina at the back of the eye to create an image of the tennis ball. Finally, this signal is sent to the brain to be processed and translated.

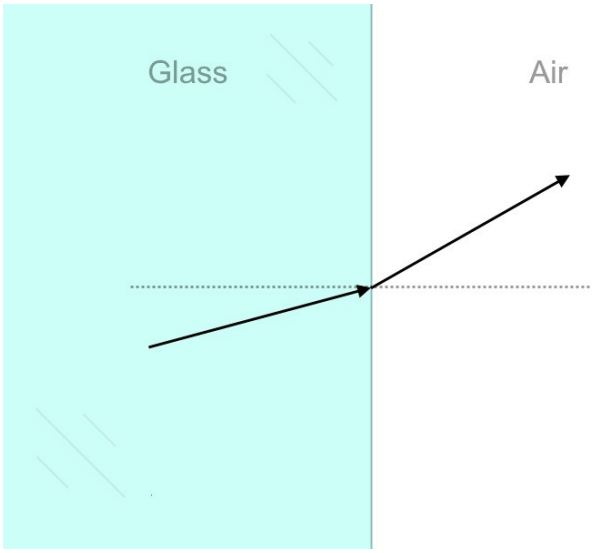
Einstein revealed to the world that the speed of light is approximately 3×10^8 m/s, but this the value for the speed of light through air. Light travels at different velocities through different media. When light enters certain media, like glass or water, it travels slower than it does in air. Different materials have corresponding values by which they slow down the speed of light. You can see this when you place a straw in a glass of water. Does the straw sometimes seem "broken" to you? That is because light travels at different velocities through the water, glass, and the air. This phenomenon is known as refraction or the bending of light. There is a specific angle at which light bends when it crosses a threshold through each medium. The corresponding mathematical value for different media that causes this bending is called the index of refraction.

This index of refraction plays a vital role in optical physics because it can help us determine at which angle light will be refracted. When light traverses to a medium of higher index of refraction, it will bend in one direction.



After crossing the threshold to a higher index, the light bends *towards* the dotted line.

If it traverses into a medium of <u>lower</u> index of refraction, it will bend in the opposite direction.



In this example, the light bends *away* from the dotted line

To complicate things, these angles are further dependent on the angle at which the ray of light also enters. Most media have indices of refraction higher than air.

Well, what does all this mumbo jumbo about geometry and angles have to do with our quasi-invisible spheres? Orbeez actually have an index of refraction <u>equal</u> to that of water. In fact, there's water *inside* of them. Prior to a demonstration, small polymer beads are given a few hours to absorb water. They expand to grow big enough to better hold in your hand. Because both

the Orbeez and the water have the same index of refraction and there is nothing in between the water and the orbs, they appear invisible!

Although they seem benign and simply a wonder to entertain children, the development of Orbeez could play a vital role in creating technology that would allow humans to turn invisible like Violet from *The Incredibles* or the Miles Morales *Spiderman.* Perhaps one day, someone will develop a material that has the same index of refraction as air and become a superhero to fight crime using stealth!

We can use science to replicate many different superpowers. The Perot Museum of Nature and Science School Programs department offers auditorium shows for schools and annual sleepovers where we explore more superhero powers and recreate them using real science.